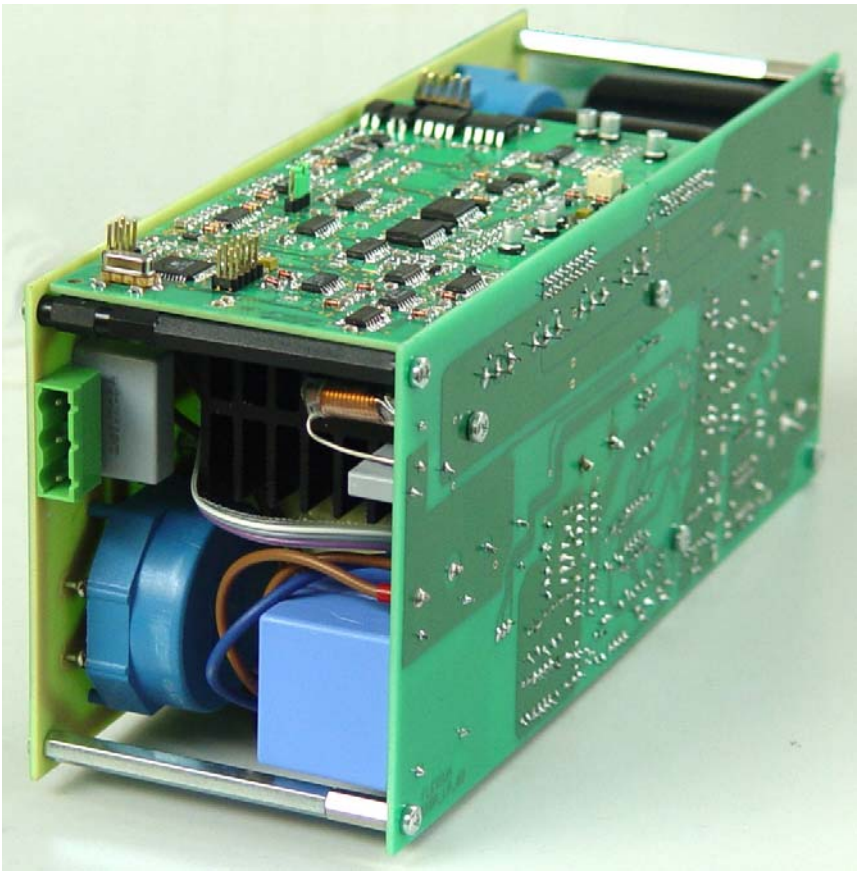
User Manual



PM3AC10

Inverter Module

FLEXIVA®
automation & Robotik

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Preface

The present Technical Documentation is to inform of the correct operation and handling of the inverter module PM3AC10 (inverter module). The modules serve to convert a direct voltage (e.g. DC link of the converter) into an alternating voltage of 230V / 50Hz.

The operating manual is to be preserved.

It is prohibited to copy or duplicate texts, plans, and tables or to make them accessible to any third parties without our express consent.

We draw your attention to the fact that the Technical Documentation shall not be part of an existing earlier agreement or promise or part of a legal relationship.

All and any obligations result from the purchase contract that also solely contains the warranty determination. The contractual provisions shall not be affected by the Technical Documentation.

The documentations of the suppliers used shall apply along with the present documentation of the manufacturer.

In addition to the operating manual, all universally valid legal and other obligatory regulations concerning the prevention of accidents and the environmental protection are to be complied with and to be instructed.

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Table of Contents

1 Introduction 6

2 Identification 7
2.1 Product Trademark and Type Designation 7
2.2 Product Version / Version of Software / Editing State 7

3 Product Description 8
3.1 General Information / Utilization as Directed 8
3.2 Technical Information and Data 9
3.3 Power Connectors 11
3.4 Signal Connections 12
3.5 Safety Information 14
3.5.1 Safety Measures for the Installation 14
3.5.2 Remaining Dangers and Risks 14
3.5.3 Qualification of the Operating Staff 15

4 Preparation of the Product for the Use 16
4.1 Transport 16
4.2 Packaging 16
4.3 Storing 16
4.4 Commissioning 16
4.4.1 Connection of the DC Link 16
4.4.2 Connection of the Output 17
4.4.3 Putting the Module into Operation 17

5 Operation 18
5.1 Method of Functioning 18
5.1.1 Modes of Operation 18
5.1.2 Safety Shutdown 19
5.1.3 Other Errors 20
5.1.4 Empty DC Link 20
5.2 Basic Parameterization 21
5.2.1 Parameters and Measured Values at the Output 21
5.2.2 Parameter and Measured Values of the DC Link 23
5.2.3 Information 24
5.2.4 Commands 25
5.2.5 Oscilloscope 25
5.3 Voltage Regulation of the DC Link 28
5.4 Typical Cases of Application / Parameterization Examples 30
5.5 Error Handling 31

6 Programming / Parameterization 32
6.1 Preliminary Remarks 32
6.2 The ASCII Protocol Used 33
6.2.1 Reading / Writing 33
6.2.2 ASCII-long / ASCII-short 35
6.2.3 Concrete Example 36
6.2.4 Error Messages 37

6.3 Communication by Means of a Terminal Software 38
6.4 Communication by Means of ModuleConfigSuite 38

7 The Parameterizing Software "ModuleConfigSuite" 39
7.1 Preliminary Remarks 39
7.2 Installation 39
7.3 Deinstallation 39
7.4 Constructional Design of the Software 40
7.4.1 Overview 40
7.4.2 Single-Mode / Multi-Mode 40
7.4.3 Groupings by Means of Colours / Backgrounds 41
7.4.4 Meaning of the Error Code 42
7.4.5 Selection and Assignment of the Interfaces 42
7.4.6 Connecting / Disconnecting 43
7.4.7 Storing / Loading of Parameter Sets 44
7.4.8 Reading-Out / Parameterizing 44
7.4.9 Data Visualization / Recording 45

8 Maintenance Service and Repair by the After-Sales Service Division 47

Table of Figures

Fig. 1: Power connectors....11
Fig. 2: Signal connections....12
Fig. 3: Block diagram of the voltage control....28
Fig. 4: Module parameterization by means of a terminal software....38
Fig. 5: Constructional design of the software....40
Fig. 6: Single-mode /module 4....40
Fig. 7: Multi-mode....41
Fig. 8: Example for groupings....41
Fig. 9 : Colour legend....41
Fig. 10: Example error codes....42
Fig. 11: Meaning error codes....42
Fig. 12: Assignment of the interfaces....43
Fig. 13: Information in case of the cutting-off of the connection....43
Fig. 14: Dialogue for the loading of parameter set files....44
Fig. 15: Buttons for the reading-out / parameterizing in the single-mode....45
Fig. 16: Dialogue field storing / visualizing....46
Fig. 17: Recorded ASCII data....46

Table of Tables

Tab. 1: Pin assignment SV3....13
Tab. 2: Modes of operation....19
Tab. 3: Error codes....20
Tab. 4: Modes of operation of oscilloscope....26
Tab. 5: Status values of oscilloscope....27
Tab. 6: Settings RS232....32
Tab. 7: Instruction sequences in general....33
Tab. 8: Complete table of the instruction codes....34
Tab. 9: Module answer for the reading of a parameter / value....35
Tab. 10: Module answer for the writing of a parameter / value....35
Tab. 11: Protocol changeover....35
Tab. 12: Reading ASCII-long....36
Tab. 13: Reading ASCII-short....36
Tab. 14: Writing ASCII-long....36
Tab. 15: Writing ASCII-short....36
Tab. 16: Error messages....37

1 Introduction

In order to guarantee the safety of the operator and to avoid possible damages at the module, you have to ensure by all means that the present user's manual has been read completely before starting to use the module and/or the plant connected with it.

The present user's manual is to help you to get to know the inverter module better and to enable you to use it according to the intended working possibilities.

Prior to the commissioning, the operating staff has to familiarize itself with all sub-units and their functions. Particular attention is to be paid to the paragraph safety.

The present user's manual contains important information on the correct and economical application of the inverter modules. The compliance with these instructions contributes to the fact that dangers are avoided, costs owing to repairs and breakdown times are reduced, and the service life of the module is prolonged.

A symbol is provided at the text margin in the chapters if required that refers to the function of the respective text section and is of importance with regard to the operation or the maintenance and/or indicates important descriptions or notes:

Danger

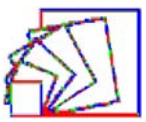
All sections in the manual containing information on possible dangers are marked with the marginal symbol.
The non-observance can lead to serious injuries! The instructions are to be strictly complied with.

Attention

All sections with this symbol provide instructions how to avoid damages at the unit.

Advice

Sections with this symbol give important details for an efficient work.



The work steps that are described in logical order at the side of this symbol inform the operator of the most ergonomic proceeding of the operation.

2 Identification

2.1 Product Trademark and Type Designation

ZEMIS® PM3AC10

2.2 Product Version / Version of Software / Editing State

Product Version:	PM3AC10-00
Firmware:	01.19
State:	2012

3 Product Description

3.1 General Information / Utilization as Directed

The inverter module serves to generate an alternating voltage from a direct voltage (e.g. DC link voltage of 375V). It is intended to be used in connection with the DC/DC converter modules of the type PM3Kxxx. Both, island operation and mains operation, are possible with the inverter module i.e. it is possible to operate a single consumer as well as to feed into the power supply system.

Attention

The inverter module does not offer any galvanic isolation of the DC link and the output! In case of the interconnection with other modules without galvanic isolation, this can lead to the damaging of the inverter module.

Terms and abbreviations

DC link:	DC link (DC side) – this is the designation for the side of the module by means of which the coupling with DC/CC modules or the link of any other 380V DC component can be carried out.
Output:	Output (AC side)
Mains operation:	In the mains operation, the inverter module is connected to the electric network and works as a current source. In this case, the feeding into the power supply system and the drawing of current from the system is possible.
Island operation:	In the island operation, consumers can be directly connected to the inverter module. It works as a voltage source.

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3.2 Technical Information and Data

Type: parameterization-reversible mains and/or island inverter with sinusoidal output variable for the operation at a DC link

Performance data:

DC link voltage:	360-390V
Nominal current:	10Aeff
Output voltage:	0-250Veff
Nominal frequency:	50Hz, 60Hz
Frequency range of island operation:	40Hz-70Hz
Overload capability of the island operation:	16Aeff (rectangle) for max. 30s
Interfaces:	RS232 (CMOS level), galvanically isolated
Power supply:	by means of the DC-link side (> 100V DC) by means of the Component side (> 100V AC)
Own requirements:	stand by: approx. 5 W
Interconnection of outputs:	cannot be connected in parallel
Galvanic isolation:	none

Environmental conditions:

Ambient temperature range	-20..50°C (during the operation)
Degree of protection	IP 00
Max. air humidity	up to 90% (not condensing)
Contaminants	The environment must not contain larger quantities of dust, in particular no metal or graphite dust.

Housing

Design	open frame
Dimensions	230 mm x 80 mm x 100 mm
Own weight	approx. 1.3 kg

Scope of delivery

- Inverter modules PM3AC10 (preparameterized)
- Data carrier (CD)
- Parameter sets for current applications (on CD)
- Software for the visualization and parameterization (on CD)
- User manual (on CD)

Optional

- Device system for max. 4 modules (variants on request)
- Preparameterization according to the planned utilization
- Initial commissioning on the customer's premises

3.3 Power Connectors

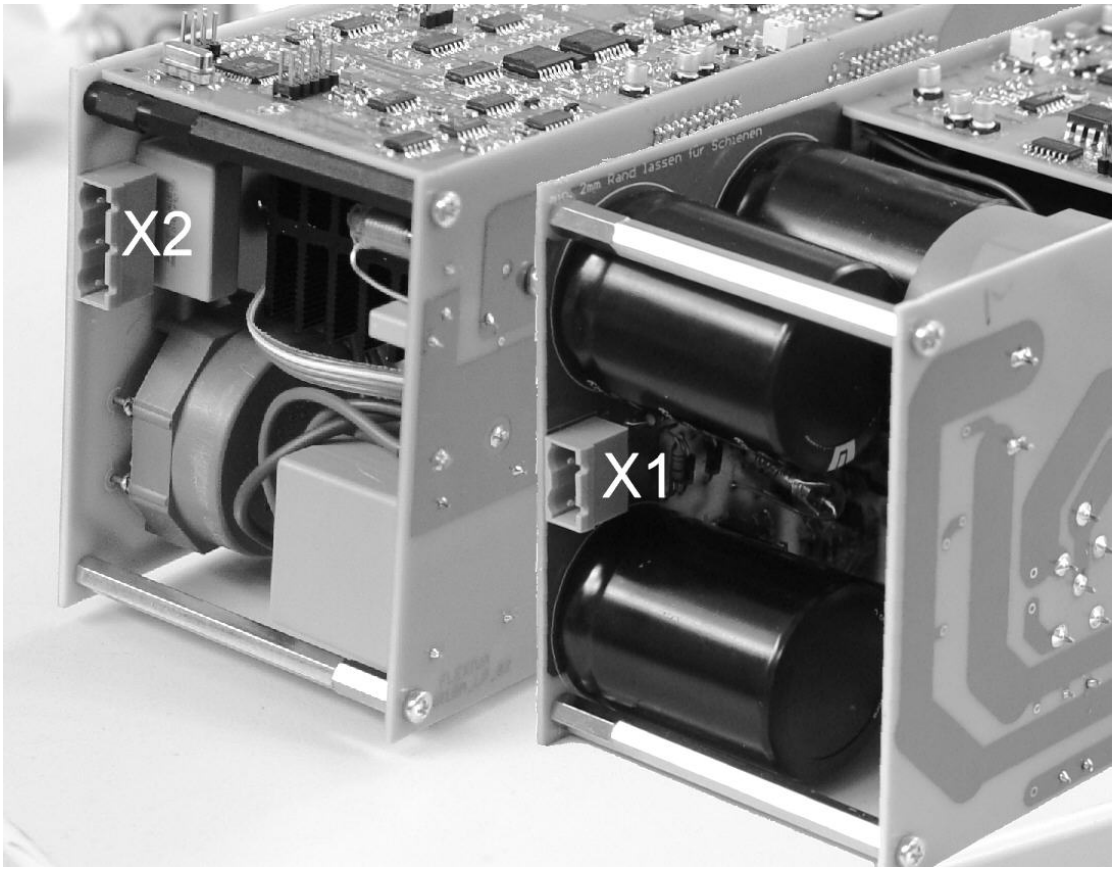

Fig. 1: Power connectors

X1: DC link

- Plug with clamp max. 2.5mm²

X2: Output

- Plug with clamp max. 2.5mm²
- L1, L2, PE

3.4 Signal Connections

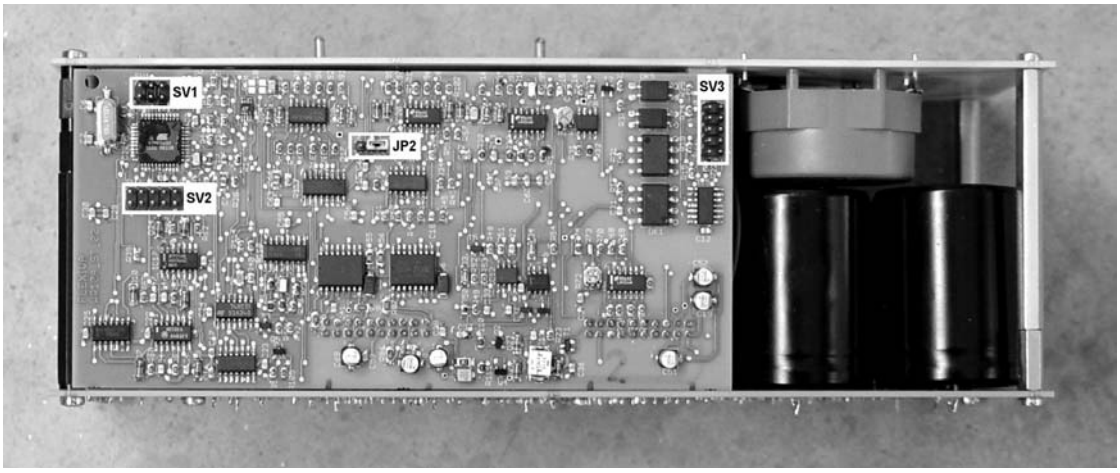

Fig. 2: Signal connections

JP2: no longer existing

SV3: Communication interface

The communication with the module is executed by means of an optically isolated serial interface: To trigger the optocouplers, a supply voltage of 5V (approx. 30mA) is to be provided. To permit to address several modules in a simple way, the signals RXD and TXD can be switched-in by means of the SELECT signal. When SELECT is low, TXD becomes a high-resistance value and RXD does not receive any signals. When several modules are used, the RXD and TXD lines can be connected in parallel this way and the currently addressed module can be selected by means of SELECT.

Data rate: 115200 bps,

Format: 8 bit + 1 stop bit

The signals OC_OK and OC_EN are provided for an additional safety feature: OC_OK gets low, when the DC link voltage has exceeded the upper limit value. Consequently, a module can inform all the others when this case has occurred by AND-combining all OC - OK signals and supplying them to OC - EN. This way, it is possible to prevent major damages when the voltage-measuring amplifier of the DC link of a module breaks down.

pin	abbreviation	explanation
1	GND	ground
2	VCC	+5 V
3	OC_OK	H: no overvoltage of the DC link
4	NC	not used
5	NC	not used
6	SELECT	H: serial interface activated L: serial interface deactivated
7	OC_EN	H: module enabled
8	RXD	input of data
9	NC	not used
10	TXD	output of data

Tab. 1: Pin assignment SV3

SV1 / SV2: Service interfaces

SV1 and SV2 are programming interfaces for the microcontrollers of the module. They are not needed for the operation and are not to be used.

3.5 Safety Information

The inverter modules were developed according to recognized rules of technology and submitted to a safety test before the delivery.

In case of wrong operations or unauthorized use, there are still dangers for persons and the inverter modules.

All persons who erect, operate, or maintain the system must:

1. read and exactly follow the present operating manual
2. be trained and instructed for their job

Test voltage between DC link side and communication interface 6kVp

3.5.1 Safety Measures for the Installation

In order to guarantee a troublefree operation and to maintain the service life of the electronic components, any accumulation of heat, especially at the fronts of the module (fan and opposite side) is to be avoided. The place of installation is to be selected so that the module is sufficiently ventilated during the operation.

Attention

The heat sinks are connected with potentials i.e. it is prohibited to touch them!

3.5.2 Remaining Dangers and Risks

The described product is in keeping with the latest technological development and meets the recognized safety provisions. Nevertheless, dangers and risks may arise.

The remaining dangers and risks occurring in connection with the operation of the system result from:

- the utilization of electric / electronic components (sources, acceptors, memories) of third-party suppliers,
- the electricity itself.

For all components built-in, the provisions and safety instructions with regard to the operation and the place of erection and/or installation applying to each of them are to be observed and complied with.

3.5.3 Qualification of the Operating Staff

Only such persons are authorized to commission and connect the module who have an electro-technical special training and who are able to execute the required line connections expertly.

Basic knowledge of the work on PCs and with the current WINDOWS operating system is required to use the software supplied along with the modules. Details about this are contained in the enclosed extensive program description.

4 Preparation of the Product for the Use

4.1 Transport

For the transport of the module, attention has to be to the fact that it is not exposed to any vibrations, heavy shocks as well as jolts and impacts since sensitive components might be damaged by that.

4.2 Packaging

Basically, packaging is to be used for the transport and/or shipment of the module that meets the requirements of the destination and the system and is environmentally acceptable.

Since the module itself has a degree of protection IP00, a transport packing is to be selected that prevents the penetrating of water, dirt, and dust. The inserting of conventional desiccating means in the packaging is recommended.

4.3 Storing

Durable storing: closed rooms, dry, room temperature

4.4 Commissioning

Prior to the commissioning, the following conditions are to be assured and to be checked:

- The expert installation and rating of all necessary electrical connection lines as well as the correct connection of all components to the module.
- The knowledge of the information and instructions given in the present user's manual.

4.4.1 Connection of the DC Link

- The cross section of the wires has to be selected according to the current expected → 1.5mm² are recommended.
- Take into account the polarity.

4.4.2 Connection of the Output

- The cross section of the wires has to be selected according to the current expected → 1.5mm² are recommended.

4.4.3 Putting the Module into Operation

1. Read the present documentation!
2. Apply the DC Link voltage.
   At a DC Link voltage of approx. 100V DC or an output-side voltage of approx. 100V AC, it is possible to communicate with the module via the serial interface.
3. Parameterize it
4. Switch it on

5 Operation

5.1 Method of Functioning

The inverter module is suited for the supply of directly connected consumers (island operation). In this case, the output voltage is kept at a constant level. The operation at an electrical network (mains operation) is possible, too. Here, the output current is kept at a constant level. In this mode of operation, a bidirectional working is possible i.e. power can also be drawn from the network and supplied to the DC link. For the changeover between the two, the parameter for the mode of operation of the module (mod_opmode) has to be reset.

The output variables current and voltage are regulated by the hardware, the desired value is given by the controller. For the control of the DC link voltage, a PIT1 controller is available that is realized by means of software and the output of which is connected with the desired values for the output variable and, thus, offers various possibilities for the voltage control of the DC link.

5.1.1 Modes of Operation

The inverter module offers various modes of operation.

In the modes of operation 0 and 1, it works in island operation. In the mode of operation 0, the voltage regulator of the DC link is switched-off. An overload i.e. when the inverter draws more power from the DC link than flows-in at another point results in an undervoltage trip because of a too low DC link voltage. This is prevented in the mode of operation 1 by the fact that voltage regulator of the DC link reduces the desired value of the output voltage and, thus, takes precautions against a DC link voltage collapse. This mode of operation is recommended for loads taking up high starting currents. In case of a long-term overload, there is also a switching-off executed.

During the switching-on, the following automatic sequence of operations is carried out in the inverter module in the modes of operation 0 and 1:

- Switching-on of the relay,
- Checking of the output with regard to absence of power,
- Switching-on of the inverter.

The modes of operation 2 and 3 serve for the operation of the inverter at an electrical network. In this case, the inverter works as current source.

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parameter: mod_opmode										
Bit								Dec	Hex	Mode of operation
7	6	5	4	3	2	1	0			
0	0	0	0	0	0	0	0	0	0x00	Island operation
0	0	0	0	0	0	0	1	1	0x01	Island operation U_ZK bounded below
0	0	0	0	0	0	1	0	2	0x02	Mains operation U_ZK bounded above
0	0	0	0	0	0	1	1	3	0x03	Mains operation U_ZK bounded below

Tab. 2: Modes of operation

5.1.2 Safety Shutdown

Apart from the already mentioned interconnected monitoring of DC link voltage, the inverter module is also equipped with an overcurrent switch-off realized by the hardware in case of a too high output current.

All other monitoring functions are realized by the software.
Altogether, the following are available:

- Shutdown in case of excess temperature
- Shutdown in case of undervoltage at the DC link
- Shutdown in case of a too high deviation from the nominal frequency in the mains operation
- Shutdown in case of overload in the island operation
- Monitoring of the output voltage
  In case of island operation, there must not be any voltage available, in the mains operation, there must be voltage available.
- Shutdown in case of failed synchronization with the mains frequency

For the excess temperature shutdown, the temperature of the heat sink element is monitored. At a temperature of more than 93 °C at the heat sink element, the shutdown is carried out.

When the voltage at the DC link drops below zk_Umin_g, the inverter is switched off.

In the mains operation, the frequency of the inverter is constantly adjusted according to the mains frequency by means of PLL. If it differs too much (0.5Hz) from the desired value, the shutdown is executed. Furthermore, the mains voltage is monitored. If it differs by +-10% from the desired value, the shutdown is carried out.

In the island operation, both the root-mean-square value of the current and the voltage are monitored. When the output current exceeds a value of 10.5A for more

than 30s, a shutdown is carried through. When the output voltage is smaller than the desired value for more than 30s owing to the voltage regulation of the DC link by overload, the shutdown is executed.

Prior to the switching-on, the existence of a voltage at the output is checked. If there is no voltage available in the mains operation or if there is a voltage detected in the island operation, the process is stopped with an error message.

When the synchronization fails in the mains operation, e.g. because the mains frequency does not correspond with the nominal frequency, the process is stopped with an error message.

All errors are filed in the variable mod_state and have to be acknowledged and consequently reset by putting err_quit on 1.

parameter: mod_state											
Bit								Dec	Hex	Meaning in the mains operation	Meaning in the island operation
7	6	5	4	3	2	1	0				
0	0	0	0	0	0	0	0	0	0x00	no error	no error
0	0	0	0	0	0	0	1	1	0x01	overcurrent at the output	overcurrent at the output
0	0	0	0	0	0	1	0	2	0x02	U_ZK too high/low	U_ZK too high/low
0	0	0	0	0	1	0	0	4	0x04	excess temperature	excess temperature
0	0	0	0	1	0	0	0	8	0x08	-	-
0	0	0	1	0	0	0	0	16	0x10	frequency deviation	overload
0	0	1	0	0	0	0	0	32	0x20	synchronization impossible	-
0	1	0	0	0	0	0	0	64	0x40	no mains voltage	output not voltage-free
1	0	0	0	0	0	0	0	128	0x80	hardware error	hardware error

Tab. 3: Error codes

5.1.3 Other Errors

Furthermore, there is the message hardware error (bit 7, hex 0x80). This occurs when there has a problem in the power supply arisen or when the overvoltage shutdown of the DC link of another module has responded and the signal OC_EN is low at the communication interface.

5.1.4 Empty DC Link

When the DC link voltage is smaller than 100V, the module is out of action since it is completely supplied with the help of the DC link side (the DC link itself). Only at a voltage exceeding 100V, the communication with the module is possible.

It is also possible to supply the module with the help of the component side (e.g. if a mains is connected there). If the mains voltage is higher than 100V, it is possible to communicate with the module and carry out the switching-on.

5.2 Basic Parameterization

The module can only be parameterized by means of the serial interface. It is, however, more convenient to do this by means of the software belonging to it.

R read

W write (parameterizable)

E stored in the EEPROM

B can be changed in switched-on state (mod_on=1)

5.2.1 Parameters and Measured Values at the Output

parameter	**a_fsoll**	
description	desired value frequency in the mains operation	
explanation	scaling: 40Hz..70Hz -> 4000..7000	
instruction	WF	**RW**

parameter	**a_fsoll_f**	
description	desired value frequency in the mains operation, initial value in the EEPROM	
explanation	scaling: 40Hz..70Hz -> 4000..7000	
instruction	WG	**RW E**

parameter	**a_fist**	
description	actual value frequency	
explanation	scaling: 40Hz..70Hz -> 4000..7000	
instruction	WH	**R**

parameter	**a_phase**	
description	phase angle of the current in the mains operation	
explanation	scaling: -90°..90° -> -90..90	
instruction	WP	**RW**

parameter	**a_phase_f**	
description	phase angle of the current in the mains operation, initial value in the EEPROM	
explanation	scaling: -90°..90° -> -90..90	
instruction	WQ	**RW E**

parameter	**a_isoll**	
description	desired value output current mains operation	
explanation	scaling: -10A..10A -> -1000..1000	
instruction	WI	**RW B**

parameter	**a_isoll_f**	
description	desired value output current mains operation, initial value in the EEPROM	
explanation	scaling: -10A..10A -> -1000..1000	
instruction	WJ	**RW E**

parameter	**a_usoll**	
description	desired value output voltage	
explanation	scaling: 0..260V -> 0..2600	
instruction	WU	**RW B**

parameter	**a_usoll_f**	
description	desired value output voltage, initial value in the EEPROM	
explanation	scaling: 0..260V -> 0..2600	
instruction	WV	**RW E**

parameter	**a_ueff**	
description	r.m.s. value output voltage measured	
explanation	scaling: 0..405V -> 0..4050	
instruction	VU	**R**

parameter	**a_ieff**	
description	r.m.s. value output current measured	
explanation	scaling: 0..20A -> 0..2000	
instruction	VI	**R**

parameter	**a_p**	
description	mean value output power	
explanation	scaling: -8000W..8000W -> -8000..8000	
instruction	VP	**R**

parameter	**a_udc**	
description	zero-frequency quantity output voltage	
explanation	scaling: -1,95V..1,95V -> -1950..1950	
instruction	VD	**R**

parameter	**a_iampl**	
description	actual amplitude current mains operation	
explanation	scaling: -10Aeff..10Aeff -> -1000..1000	
instruction	VJ	**R**

Parameter	**a_uampl**	
description	actual amplitude voltage island operation	
explanation	scaling: 0..260V -> 0..2600	
instruction	VV	**R**

5.2.2 Parameter and Measured Values of the DC Link

parameter	**zk_usoll**	
description	desired value DC link voltage	
explanation	scaling: 350V..400V -> 3500..4000	
instruction	ZU	**RW B**

parameter	**zk_usoll_f**	
description	desired value DC link voltage, initial value in the EEPROM	
explanation	scaling: 350V..400V -> 3500..4000	
instruction	VN	**RW E**

parameter	**zk_uist**	
description	actual value DC link voltage	
explanation	scaling: 350V..400V -> 3500..4000	
instruction	ZA	**R**

Attention

The DC link voltage is only measured in the range of 350V to 400V. If it is smaller than 350V, the value 3500 is output. Before work is done at the DC link cabling the DC link voltage has to be measured and the DC link must be discharged.

parameter	**zk_umax_g**	
description	upper limit	
explanation	scaling: 350V..400V -> 3500..4000 not used	
instruction	ZM	**RW E**

parameter	**zk_umin_g**	
description	lower limit	
explanation	scaling: 350V..400V -> 3500..4000 when it is less than this value, the undervoltage trip is executed(error: 0x02)	
instruction	ZN	**RW E**

parameter	**zk_ki**	
description	I component voltage regulator of DC link	
explanation	parameter range: 0..255 transfer function: G=VI/p VI: 0..12000s-1 VI=10000s-1/256*zk_ki	
instruction	YI	**RW E**

parameter	**zk_kp**	
description	P component voltage regulator of DC link	
explanation	parameter range: 0..255 amplification: 0..255	
instruction	YP	**RW E**

parameter	**zk_kt**	
description	delay voltage regulator of DC link	
explanation	parameter range: 0..255 transfer function: G=1(1+pT) T: 102ms..0,40ms T=256/(zk_kt*2500Hz)	
instruction	YT	**RW E**

5.2.3 Information

parameter	**mod_state**	
description	module status	
explanation	error codes see Tab. 3	
instruction	IS	**R**

parameter	**mod_opmode**	
description	module mode of operation	
explanation	see Tab. 2	
instruction	IM	**RW E**

parameter	**-**	
description	module type No.	
explanation	module type (WR)	
instruction	IT	**R**

parameter	**-**	
description	module firmware	
explanation	software state of the firmware	
instruction	IF	**R**

parameter	**-**	
description	module serial No.	
explanation	serial number of the manufacturer	
instruction	IN	**R**

Parameter	**-**	
description	module man. date	
explanation	manufacturing date	
instruction	ID	**R**

Parameter	**t_kk**	
description	temperature heat sink element	
explanation	communication value 0..1000 corresponds to –273..127°C	
instruction	TK	**R**

5.2.4 Commands

parameter	**mod_on**	
description	module on / off	
explanation	1: on 0: off	
instruction	CE	**RW B**

parameter	**err_quit**	
description	acknowledging of an error	
explanation	1: acknowledging of an error	
instruction	CQ	**RW B**

parameter	**com_mode**	
description	reading-out of the communication mode	
explanation	0: ASCII short 1: ASCII long	
instruction	CC	**R B**

5.2.5 Oscilloscope

For the setting of the regulator parameters and for the observing in the operation, an oscilloscope functionality is integrated into the software. By means of it, output voltage, DC link voltage and output current can be recorded. 256 values with a resolution of 8bit are recorded. The possible scanning frequency is in the range from 2.5kHz and 9.7Hz.

The channel where triggering is done can be selected independently of the recorded channel.

In order to image the 10-bit and/or 11-bit values of voltages and currents onto the 8-bit recording range, there are various possibilities available. It is either possible to scale the complete range of values to 0...256 with the 0 being at 128 in case of I_VS. Or it is also possible to image only the amount of the positive or negative range of values from 0 to 256. Or it is possible to choose the full resolution (currents: -1,000...1,000, voltages 0...1.000) and to shift it by means of an offset in the range 0...256 of the recording.

	Scaled range	**Real range**
U_ZK	0 +1,000	350V 400V
U_A	-500 0 +500	-400V 0V +400V
I_A	-500 0 +500	-20A 0A +20A

parameter	**osz_ch**	
description	channel	
explanation	0: U_ZK (DC link voltage) 1: U_A (output voltage) 2: I_A (output current)	
instruction	OK	**RW B**

parameter	**osz_ft**	
description	frequency divider	
explanation	pulse frequency: 2.5kHz/osz_ft 0 corresponds to 2.5kHz/256	
instruction	OF	**RW B**

parameter	**osz_tr**	
description	trigger value	
explanation	trigger value for all channels between –1,000 and 1,000	
instruction	OT	**RW B**

parameter	**osz_tch**	
description	trigger channel	
explanation	0: U_ZK 1: U_A 2: I_A	
instruction	OC	**RW B**

parameter	**osz_m**	
description	storage mode	
Explanation	see Tab. 4	
instruction	OM	**RW B**

parameter: osz_m										
Bit								**Dec**	**Hex**	**Meaning**
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**			
x	x	x	x	x	x	x	0	0	0x00	triggering at value > trigger value
x	x	x	x	x	x	x	1	1	0x01	triggering at value < trigger value
x	x	x	x	x	0	0	x	0	0x00	complete range of values to 0…255
x	x	x	x	x	0	1	x	2	0x02	value(10-bit)-offset cut-off on 0..255
x	x	x	0	0	x	x	x	0	0x00	trigger position 0 %
x	x	x	0	1	x	x	x	8	0x08	trigger position 25%
x	x	x	1	0	x	x	x	16	0x10	trigger position 50%
x	x	x	1	1	x	x	x	24	0x18	trigger position 75%

Tab. 4: Modes of operation of oscilloscope

parameter	**osz_offs**	
description	offset	
explanation	for storage mode with offset	
instruction	OO	**RW B**

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Weißbacher Straße 3
D – 09439 Amtsberg

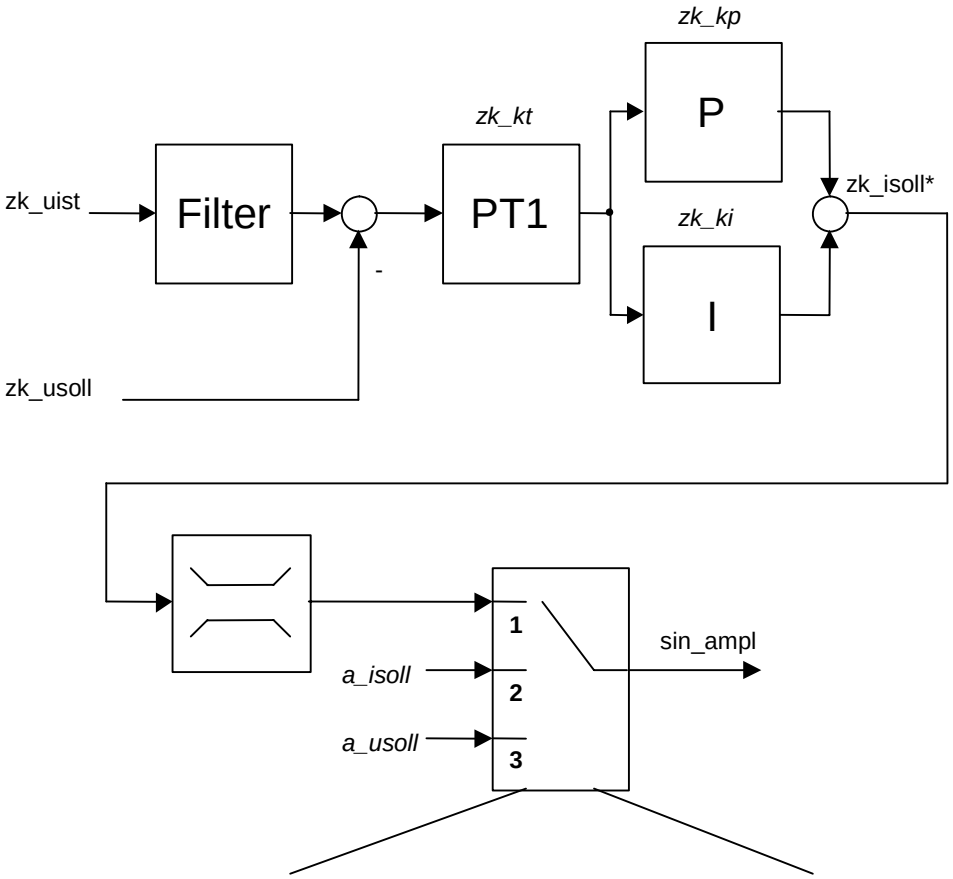
parameter	**osz_on**	
description	osci on / off	
explanation	osci starting / status	
instruction	OE	**RW B**

parameter	**-**	
description	osci reading-out	
explanation	reading-out of the 256 values (ASCII)	
instruction	OR	**R**

parameter: osz_on										
Bit								**Dec**	**Hex**	**Meaning**
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**			
0	0	0	0	0	0	0	0	0	0x00	does not run
x	x	x	x	x	x	x	1	1	0x01	runs, waits for trigger
x	x	x	x	x	x	1	x	2	0x02	runs, triggered
x	x	x	x	x	1	x	x	4	0x04	runs, run-in for pre-trigger

Tab. 5: Status values of oscilloscope

5.3 Voltage Regulation of the DC Link



Mains Operat.	mod_opmode=2	mod_opmode=3
zk_isoll*>a_isoll	1	2
zk_isoll*<a_isoll	2	1

Isolated Operat.	mod_opmode=1
zk_isoll*>a_usoll	3
zk_isoll*<a_usoll	1

Fig. 3: Block diagram of the voltage control

The voltage control of the DC link is digitally realized and designed as represented in Fig. 3. It works as follows: The measured value of the DC link voltage gets first into a filter that suppresses the 100Hz and/or 120Hz ripple factor. This filter is optimized for an operating frequency of 50Hz and/or 60Hz. The correct setting is selected on the basis of the parameter a_fsoll. When the operating frequency differs widely from 50Hz and/or 60Hz the suppression of the ripple factor of the DC link voltage is no longer optimal. Then, the comparison with the desired value and the PIT1 controller follow. The output value of this controller is then compared with the desired value of current or voltage depending on the mode of operation. This way, either the controller output value or the desired value as desired value of the amplitude get to the sine-wave generator.

Furthermore, attention is to be paid to the fact that a controller amplification that is set too high can lead to despite the filtering of the actual value of the DC link voltage.

Mains Operation

In the mains operation, the voltage control of the DC link can be used to feed excessive power into the electrical network or to draw lacking power from the electrical network. In the mode of operation 2 (mod_opmode=2), the DC link voltage is limited upwards. This can be applied when the DC link is fed from the electrical network or when only excessive power is to be supplied to the electrical network.

In the mode of operation 3 (mod_opmode=3), the DC link voltage is limited downwards. This is recommended when a constant current is to be fed into the electrical network and this is to be reduced when there too less power available in the DC link or when power is to be drawn from the electrical network while the DC link voltage is too low.

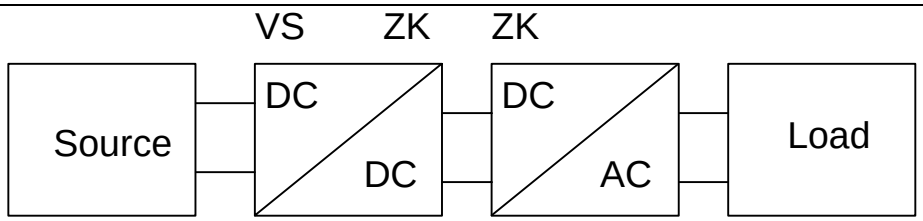
Island Operation

In the mode of operation 0 (mod_opmode=0), the voltage control of the DC link is deactivated. When the load is too big, the DC link voltage collapses in this case for that reason what leads to a shutdown of the complete system.

In the mode of operation 1 (mod_opmode=1), the output voltage is reduced when the DC link voltage is too low. It prevents a switching-off of the system. But if this state occurs for more than 30s, the shutdown is carried out because of undervoltage.

5.4 Typical Cases of Application / Parameterization Examples

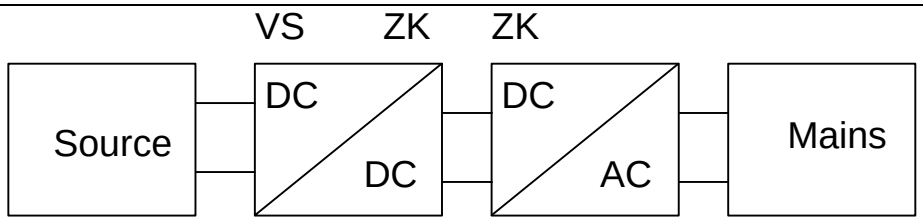
To be able to operate the inverter module in a certain arrangement, some parameters have to be placed correctly. In the following example configurations, useful instructions are given for the correct parameterization of the inverter module in connection with a DC/DC converter module of the type PM3Kxxx.

a)		
Application	any application you like	
Parameter DC/DC module to source	mod_opmode: vs_imax: vs_imin: zk_usoll: vs_usoll:	1 + desired current limit 0 desired value DC link voltage smaller than minimum input voltage
Parameter inverter module to load	mod_opmode: zk_usoll: a_usoll: a_fsoll:	0 and/or 1 desired value DC link voltage, smaller than minimally occurring DC link voltages desired output voltage desired frequency

Example a) shows the application of the inverter module in the island operation. If mod_opmode=1 is selected, the voltage control of the DC link is activated and reduces the output voltage when the DC link voltages falls below its desired value zk_usoll.

Example b) shows the application of the inverter module in the mains operation. The current fed into the electrical network can be specified in the represented configuration, the control voltage of the DC link does not work. By changing the desired value of the DC link voltage and the mode of operation, the voltage control of the DC link can be used here and have the power flow regulated automatically.

Attention has to be paid to the fact the a ripple factor of the DC link voltage is produced because of the pulsating power drawing. When the amplification of the voltage regulator of the DC link is set too high this can lead to. In addition to that, this can spread to the VS-Side (variable voltage side) owing to the voltage control of the DC link of the DC/DC converter module. Here, it helps to reduce the amplification of the voltage controller of the DC link of the DC/DC converter a little bit.

b)		
Application	any application you like	
Parameter DC/DC module to source	mod_opmode: vs_imax: vs_imin: zk_usoll: vs_usoll:	1 + desired current limit 0 desired value DC link voltage smaller than minimum input voltage
Parameter inverter module to load	mod_opmode: zk_usoll: a_isoll: a_fsoll: a_usoll:	3 desired value DC link voltage, smaller than minimally occurring DC link voltages desired output current mains frequency mains voltage

5.5 Error Handling

Acknowledging of the error, eliminating of the cause, restarting.

6 Programming / Parameterization

6.1 Preliminary Remarks

The inverter module offers a convenient software interface. All parameters / commands / measured values can be written and/or read by means of a simple ASCII protocol. All module variables no matter whether they represent a parameter, a measured value or a command are addressable by means of an instruction code consisting of two characters. The first character indicates the respective group membership, e.g. "z“ for the voltage parameters of the DC link and the second character then specifies the concrete variable. A complete list of all instruction codes is part of the present documentation.

The serial interface of the modules serves as (hardware) communication interface. It can, for example, be connected with the RS232 interface of a PC. The following settings are required:

bits per second	115200
data bits	8
parity	none
stop bits	1
flow control	none

Tab. 6: Settings RS232

6.2 The ASCII Protocol Used

The transfer of the corresponding commands in the ASCII format is done in a simple scheme. All characters transferred to the module are immediately evaluated by the same and checked with regard to their validity within the respective sequence of commands. This means concretely: If, for example, a plus/minus sign is expected at a certain point of a sequence of commands, the module only accepts the signs plus(+) or minus(-). Valid characters are directly mirrored (exceptions: control characters for the protocol changeover and CR), invalid characters are immediately rejected. Because of this, you save yourself large-scale taking down on record (test sums, length specifications, etc.) and you can nevertheless minimize incorrect entries.

6.2.1 Reading / Writing

Basically, you have to distinguish between "Reading" and "Writing" as far as the sequences of instructions to be sent to the module are concerned. If, for example, the value stored in a module variable is only to be read, you have to send the corresponding abbreviation as a sequence followed by Return, If a new value is to be stored in a variable, the corresponding abbreviation, the plus/minus sign of the new value, the new value itself and Return are to be sent.

read	**write**
instruction code + CR	instruction code + sign + new value + CR

Tab. 7: Instruction sequences in general

The following chart lists all possible instruction codes for the communication with the module and they are arranged in groups. At the same time, the names of the respective module variables as well as the place of storing and the parameterizability are shown.

Group	Description	1. Command Character	2. Command Character	parame -trizable	stored in EEPROM	Parameter
DC Link	voltage: desired value	z	u	x+		zk_usoll
(DC link side)	voltage: desired initial value	z	v	x	x	zk_usoll_f
	voltage: actual value	z	a			zk_uist
	voltage: upper Limit (not used)	z	m	x	x	zk_umax_g
	voltage: lower Limit	z	n	x	x	zk_umin_g
	I-component of the DC link regulator	y	i	x	x	zk_ki
	P-component of the DC link regulator	y	p	x	x	zk_kp
	filter time constant of the DC-link regulator	y	t	x	x	zk_kt
Output	frequency: desired value	w	f	x		a_fsoll
(component side)	frequency: desired initial value	w	g	x	x	a_fsoll_f
	frequency: actual value	w	h			a_fist
	current: phase angle, desired value	w	p	x		a_phase
	current: phase angle, desired initial value	w	q	x	x	a_phase_f
	current: desired value	w	i	x+		a_isoll
	current: desired initial value	w	j	x	x	a_isoll_f
	voltage: desired value	w	u	x+		a_usoll
	voltage: desired initial value	w	v	x	x	a_usoll_f
	voltage: r.m.s. value	v	u			a_ueff
	current: r.m.s. value	v	i			a_ieff
	power: mean value	v	p			a_p
	voltage: steady component	v	d			a_udc
	current: amplitude actual value	v	j			a_iampl
	voltage: amplitude actual value	v	v			a_uampl
Temperatures	temperature heat sink	t	k			t_kk
Info	module state	i	s			mod_state
	module operating mode	i	m	x	x	mod_opmode
	module type	i	t			
	module firmware	i	f			
	module serial number	i	n		x	
	module date of manufacture	i	d		x	
Commands	module on / off	c	e	x+		mod_on
	rrror quit	c	q	x		err_quit
	communication mode	c	c			com_mode
Oscilloscope	channel	o	k	x+		osz_ch
	frequency divider	o	f	x+		osz_ft
	trigger value	o	t	x+		osz_tr
	trigger channel	o	c	x+		osz_tch
	storage mode	o	m	x+		osz_m
	offset	o	o	x+		osz_offs
	oscilloscope on / off	o	e	x+		osz_on
	oscilloscope readout	o	r			
x+ also parametrizable, if the module is switched on (mod_on=1)						

Tab. 8: Complete table of the instruction codes

6.2.2 ASCII-long / ASCII-short

On the part of the module answer, two protocol variants are possible: "long" and "short" ASCII protocol. ASCII-long is particularly suited for the manual entry of instructions, e.g. by using a terminal program such as "HyperTerminal" from Windows. When this protocol is set, the module sends any information and (error) messages in clear text and sees to a distinct representation in the terminal program by means of the transfer of CR and NL control characters at corresponding points.

On the other hand, the protocol ASCII-short should be used when the instruction is to be handed over from another software such as, for example, from the software "ModuleConfigSuite" of Flexiva. If this protocol is set, any information and (error) messages in clear text are suppressed. In case of an error, only error codes are transferred.

	ASCII-long	**ASCII-short**
without error	- instruction code + CR + NL - sign + read value + CR + NL - „OK“ + CR + NL + NL	- instruction code + CR - sign + read value + CR
With error	- instruction code + CR + NL - error code + CR + NL - error (information) text + CR + NL + NL	- instruction code + CR - error code + CR

Tab. 9: Module answer for the reading of a parameter / value

	ASCII-long	**ASCII-short**
without error	- instruction code + sign + new value + CR + NL - sign + read back value + CR + NL - „OK“ + CR + NL + NL	- instruction code + sign + new value + CR - sign + read back value + CR
with error	- instruction code + sign + new value + CR + NL - error code + CR + NL - error (information) text + CR + NL + NL	- instruction code + sign + new value + CR - error code + CR

Tab. 10: Module answer for the writing of a parameter / value

The changeover between the two variants is executed by putting a control character in front of the respective first sequence of commands. The control character can also be sent separately. The respective protocol setting is preserved until the next protocol changeover and/or to the next restart (supply voltage gone) or reset of the module. As a standard setting, ASCII-short is set.

Protocol variant	**Control character to the module**
ASCII-short	$
ASCII-long	%

Tab. 11: Protocol changeover

6.2.3 Concrete Example

To explain the above-mentioned paragraphs, the sequences of instructions to be transferred to the module and the corresponding answers of the module are listed in the following at a concrete example. The case without errors is treated.
The module variable zk_umin_g is to be read-out and a new value is to be stored in it. The corresponding code is "zn", the old value in the variable is "+3500" and the new value is "+3600". This results for the two ASCII modes in the following communication with the module:

To the module																							
ASCII	%	z	n	CR																			
HEX	25	7A	6E	OD																			
From the module																							
ASCII		z	n	CR	NL	+	3	5	0	0	CR	NL	O	K	CR	NL	NL						
HEX		7A	6E	0D	0A	2B	33	35	30	30	0D	0A	4F	4B	0D	0A	0A						

Tab. 12: Reading ASCII-long

To the module																							
ASCII	$	z	n	CR																			
HEX	24	7A	6E	OD																			
From the module																							
ASCII		z	n	CR	+	3	5	0	0	CR													
HEX		7A	6E	0D	2B	33	35	30	30	0D													

Tab. 13: Reading ASCII-short

To the module																							
ASCII	%	z	n	+	3	6	0	0	CR														
HEX	25	7A	6E	2B	33	36	30	30	0D														
From the module																							
ASCII		z	n	+	3	6	0	0	CR	NL	+	3	6	0	0	CR	NL	O	K	CR	NL	NL	
HEX		7A	6E	2B	33	36	30	30	0D	0A	2B	33	36	30	30	0D	0A	4F	4B	0D	0A	0A	

Tab. 14: Writing ASCII-long

To the module																							
ASCII	$	z	n	+	3	6	0	0	CR														
HEX	24	7A	6E	2B	33	36	30	30	0D														
From the module																							
ASCII		z	n	+	3	6	0	0	CR	+	3	6	0	0	CR								
HEX		7A	6E	2B	33	36	30	30	0D	2B	33	36	30	30	0D								

Tab. 15: Writing ASCII-short

6.2.4 Error Messages

All sequences arriving in the module are immediately checked and processed. The following errors can occur during the reading / writing and these errors concern exclusively the parameterizing process and are not to be confused with the errors that may arise during the operation of the module and are coded in the status variable mod_state (Tab. 3):

Error code	Meaning in clear text
E0	Reserve
E1	Reserve
E2	Unknown module command
E3	Value beyond the range of values
E4	Value is only readable
E5	Device must be switched-off
E6	-
E7	Mode of operation must be <16
E8	Min value must be smaller than max value

Tab. 16: Error messages

6.3 Communication by Means of a Terminal Software

Because of the utilization of an ASCII protocol for the communication interface, a communication with the module is possible by means if any terminal software you like. As an example, HyperTerminal is mentioned here that exists in Windows as a standard outfit (see Fig. 4). Of course, every other software can be also applied (Freeware, self-developed software) by means of which a bidirectional serial communication is possible. For the utilization of Terminal Software, the protocol setting ASCII-long is recommended.

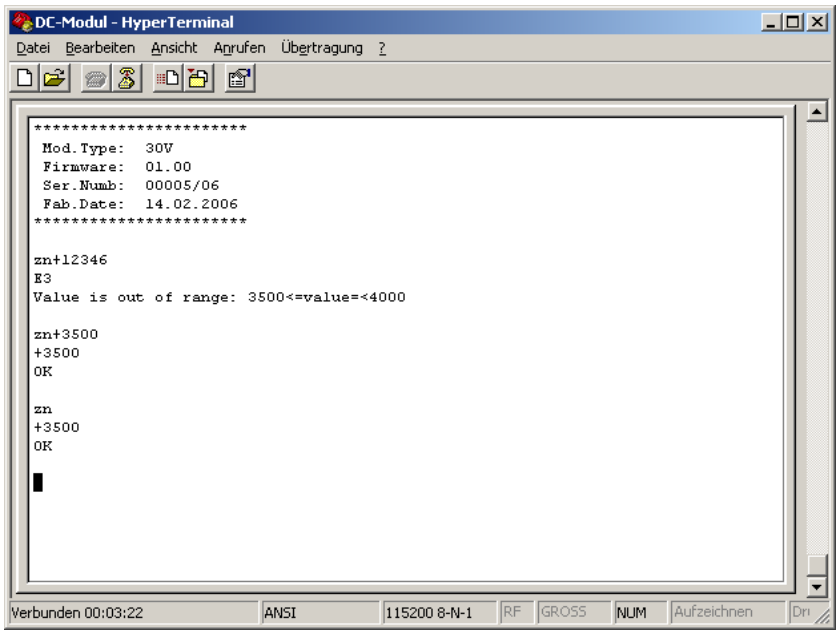


Fig. 4: Module parameterization by means of a terminal software

6.4 Communication by Means of ModuleConfigSuite

Another and much more convenient possibility is the utilization of the Windows software "ModuleConfigSuite" from the company Flexiva that is contained in the scope of delivery of the inverter module as a standard component. This software permits a convenient communication and a closed access (parameterizing / monitoring / storing) to all variables (parameters / commands / measured values) of every single module. Furthermore, it is possible to communicate simultaneously with up to 4 modules. The ModuleConfigSuite uses the protocol setting ASCII-short.

7 The Parameterizing Software "ModuleConfigSuite"

7.1 Preliminary Remarks

A Windows software for the PC is supplied along with the module. It is intended for the convenient parameterization and visualization of all parameters / commands / measured values as well as for the recording of select data on the fixed disk. In the following, details concerning the function and operation of this software are explained.

System Prerequisites

Hardware:
- customary PC of medium performance and RS232 interface

Operating system:
- MS Windows (from Windows XP SP2 onwards)

7.2 Installation

The software is installed like any other conventional Windows software:

1. Insert the data carrier.
2. Start the installation by means of starting the file **setup.exe**.
3. Follow the instructions given by the installation program (path entry etc.).
   a. Installation step backwards by means of a click onto **Back**
   b. Installation step forwards by means of a click onto **Next**
   c. Stop the installation by means of a click onto **Cancel**
4. Terminate the installation by means of a click onto **Finish**

7.3 Deinstallation

If the software is to be removed from the fixed disk, you proceed as follows:

1. Open the **Start menu** of Windows.
2. Select **System control**.
3. In the system control panel click onto the symbol **Software**.
   A list of the available programs is displayed.
4. Select from the list the symbol for **ModuleConfigSuite**.
5. Click onto **Remove**. The software is de-installed now.

7.4 Constructional Design of the Software

7.4.1 Overview

After the start of the software and the successful establishing of a connection to one or several modules (click on "Connect!" in the menu line), the following window is displayed in which a division into three parts that is into a menu line, a button bar directly under the menu line and the remaining display area can be recognized. Only those modules are displayed with which a connection is to be established (see paragraph "Selection and Assignment of the Interfaces“) and a connection was successfully established.

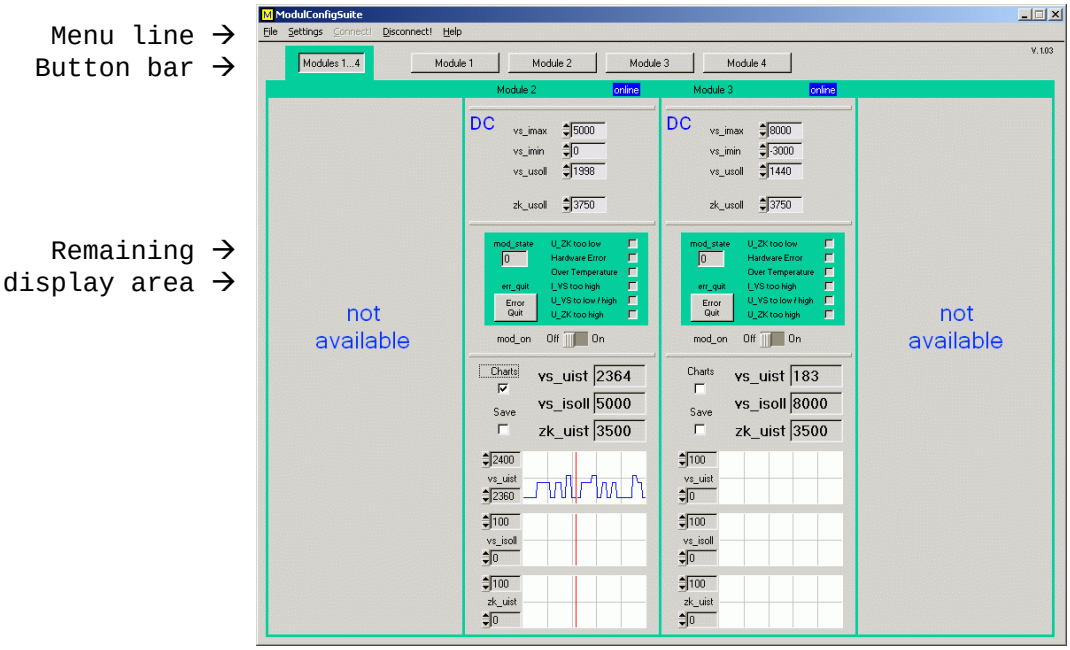


Fig. 5: Constructional design of the software

7.4.2 Single-Mode / Multi-Mode

On principle, the software distinguishes between two modes, the so-called "Single"-mode for the communication with only one single module and the so-called "Multi"-mode for the simultaneous communication with up to 4 modules.
The changeover between the modes is executed by means of the buttons in the upper window area.

Fig. 6: Single-mode /module 4

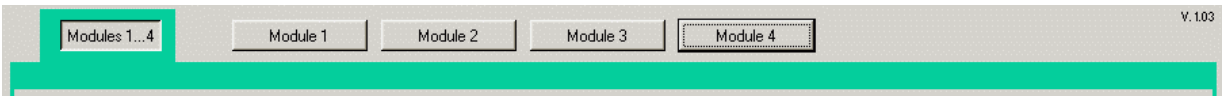


Fig. 7: Multi-mode

After the start of the software, the Multi-mode is automatically set.

7.4.3 Groupings by Means of Colours / Backgrounds

Owing to the great number of information to be represented at the same time and the diversity of the entries to be processed, the application of different colours for the logical grouping turned out to be advantageous. The legend with

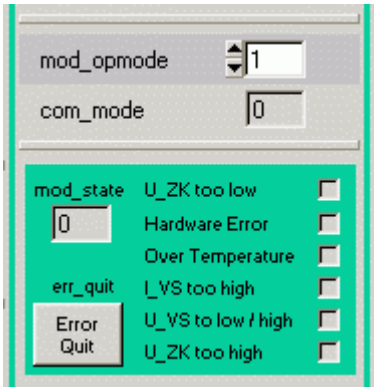


Fig. 8: Example for groupings

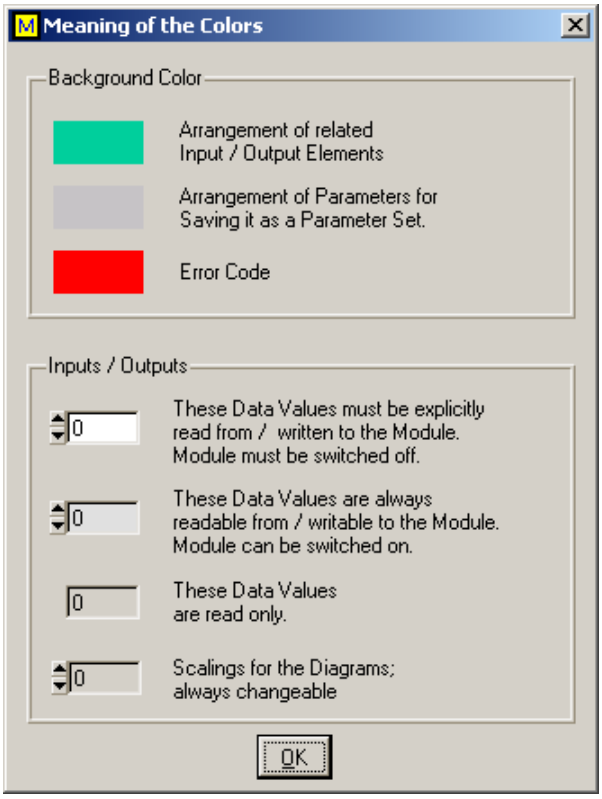

Meaning of the Colors
Background Color
Arrangement of related Input / Output Elements
Arrangement of Parameters for Saving it as a Parameter Set.
Error Code
Inputs / Outputs
These Data Values must be explicitly read from / written to the Module. Module must be switched off.
These Data Values are always readable from / writable to the Module. Module can be switched on.
These Data Values are read only.
Scalings for the Diagrams; always changeable
OK

Fig. 9 : Colour legend

the explanation of the colours can be called after the selection of the menu item "Help → Color Codes".

7.4.4 Meaning of the Error Code

All data that are transferred (for example, by a click onto one of the buttons "Write Values" in the single-mode) to the module, are immediately checked there with regard to their validity. In case of an error, the corresponding error code is entered in a red field directly next to the respective display / entry element.

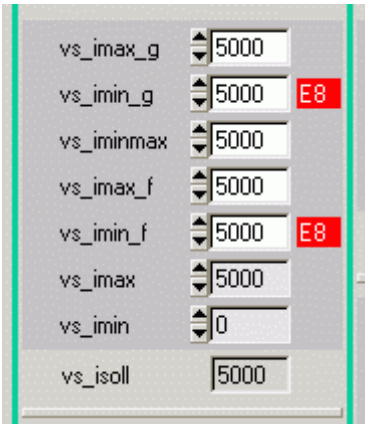


Fig. 10: Example error codes

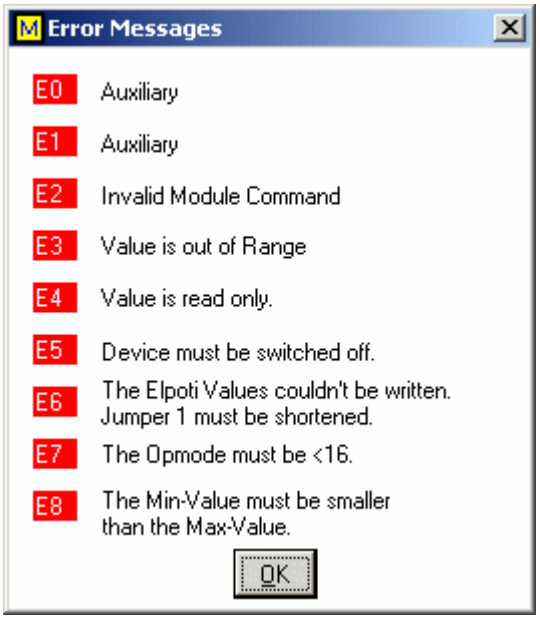

Error Messages
E0 Auxiliary
E1 Auxiliary
E2 Invalid Module Command
E3 Value is out of Range
E4 Value is read only.
E5 Device must be switched off.
E6 The Elpoti Values couldn't be written. Jumper 1 must be shortened.
E7 The Opmode must be <16.
E8 The Min-Value must be smaller than the Max-Value.
OK

Fig. 11: Meaning error codes

A legend with the meaning of the error codes can be called by the selection of the menu item "Help → Error Codes").

7.4.5 Selection and Assignment of the Interfaces

The selection of the interfaces and their assignment to the modules is carried out by the selection of the menu item "Settings → Connection". Depending on the type of the module carrier, there are various possibilities available. In case of the module carrier of the type 1, the communication is executed by means of 4 separate RS232 interfaces (one for every module). The module carrier of the type 2 needs only one RS232 for the communication with all modules (is multiplexed in the module carrier). In case of the module carrier of the type 3 at last, a network interface is available (TCP/IP protocol).

In addition to the assignment of the interfaces, you also have to select explicitly by marking a checkbox in the variants 2 and 3 in the configuration dialogue whether communication with the respective module is intended. This offers the possibility to fade-in or fade-out individual modules.

During the selection and assignment of the interfaces, tests are carried through concerning the existence in the PC and/or double bindings.

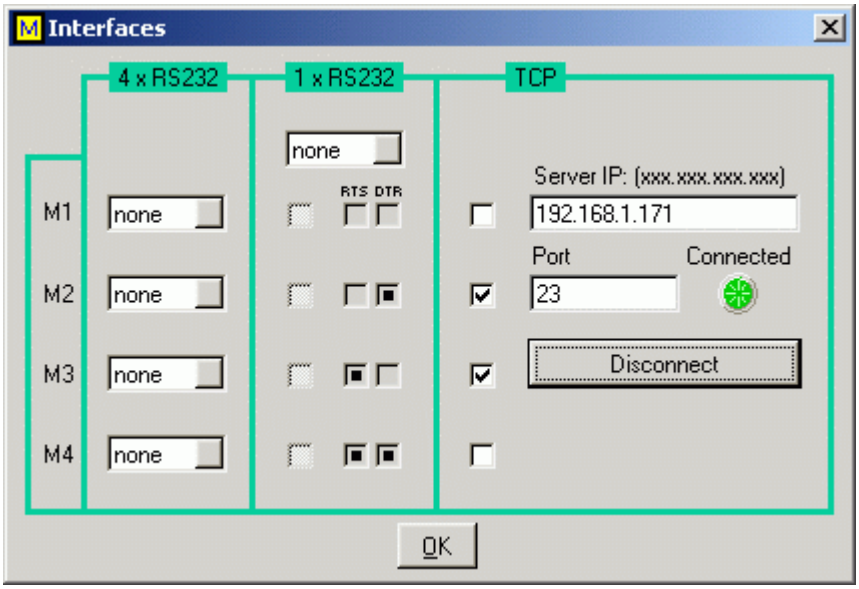


Fig. 12: Assignment of the interfaces

Attention: Only a test of the chosen interfaces and their assignment to the modules is made. The data connection to the modules is only established after the selection of the menu item "Connect!".

7.4.6 Connecting / Disconnecting

By the selection of the menu item "Connect!", it is possible to establish a data connection to the corresponding module (single-mode) and/or to the modules multi-mode). In the single-mode, all data are read-out once completely from the chosen module after the successful establishing of the connection and entered into the respective fields of the screen mask. In the multi-mode, only the relevant data are read-out after the successful establishing of the connection and entered into the respective fields of the screen mask. A selection of the menu item "Disconnect!" cut(s)-off the connection(s).

Fig. 13: Information in case of the cutting-off of the connection

The connection is permanently monitored both during the establishing of the connection and during the existing connection. If the establishing of the connection fails and/or the connection is cut-off a corresponding information is provided.

7.4.7 Storing / Loading of Parameter Sets

In the single-mode, it is possible to store parameter sets on the fixed disk and/or to load parameter sets that are stored on the fixed disk. After the calling of the menu items "File → Load Parameter Set" and/or "File → Save Parameter Set", the corresponding dialogues are called for the loading and storing of files. The parameter files have got a special format that can only be read and write by the ModuleConfigSuite. As a standard outfit, the have the file extension *._ac.

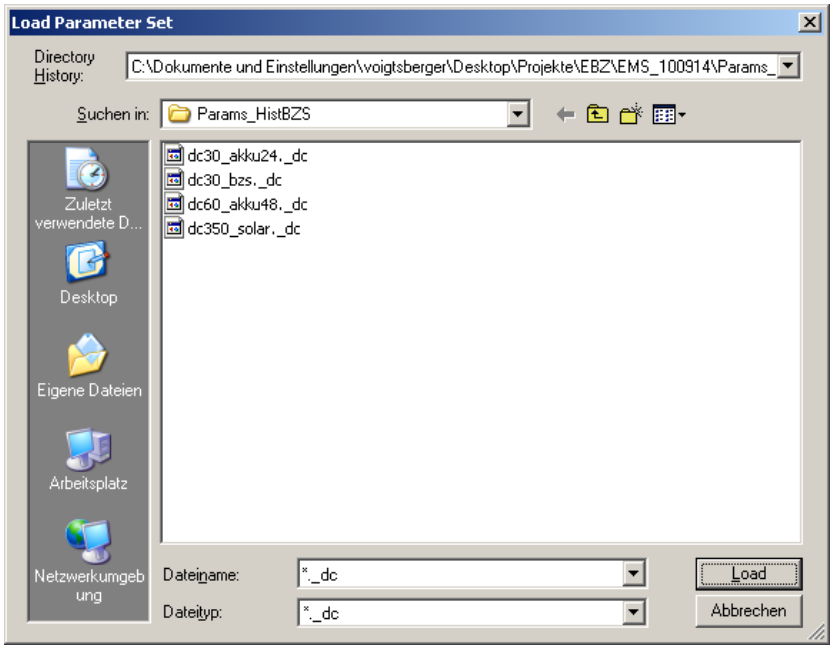


Fig. 14: Dialogue for the loading of parameter set files

When such a file is loaded from the fixed disk, all parameters are immediately entered into the corresponding fields. In the reverse case, only the corresponding fields are read-out for the storing of the parameters in such a file. Only such fields with the respective coloured background are taken into account.

7.4.8 Reading-Out / Parameterizing

All relevant data are automatically read-out from the module and/or the modules during the changeover between the two main modes single-mode and multi-mode (buttons: "Modules 1…4" and "Module 1" … "Module 4") or during the establishing of

the connection ("Connect!"). In the single-mode, all data are read-out from the selected module and entered into the corresponding fields of the screen mask, in the multi-mode only the relevant ones. The requirement is in both modes an existing data connection to the respective module and/or to the respective modules.
In addition to that, it is possible in the single-mode to explicitly initiate the reading-out of the data from the module and/or the storing of data in the module by means of a click onto one of the buttons "Read Values" or "Write Values". Only the data of the respective column (e.g. "DC link") are taken into account during this.

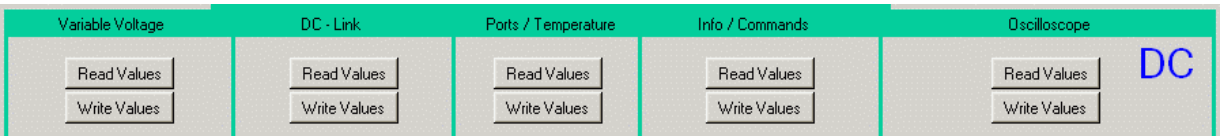


Fig. 15: Buttons for the reading-out / parameterizing in the single-mode

Both in the single-mode and in the multi-mode, some data are immediately transferred after their entry / modification (see colour codes). These are in particular the parameters: a_isoll, a_usoll and zk_usoll.

7.4.9 Data Visualization / Recording

Both in the single-mode and in the multi-mode, the parameters a_ueff, a_ieff, zk_uist and mod_state are permanently read-out and visualized with a transfer rate of constantly 10 Hz when the connection exists. If the check boxes "Charts" and "Save" are marked, in addition to that, the three parameters a_ueff, a_ieff, zk_uist are simultaneously visualized in diagrams and data are stored (data-logging) in the ASCII format.

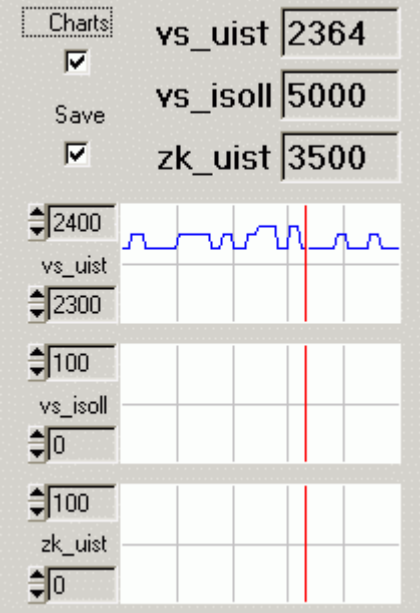


Fig. 16: Dialogue field storing / visualizing

zk_uist	a_ueff	a_ieff
4011	5710	3069
4011	6810	3069
4011	5710	3069
4011	6730	3069
4011	5550	3069
4011	5095	3069
4011	6340	3069
4011	5315	3069
4011	6260	3069
4011	5785	3069
4011	6575	3069
4011	5710	3069
4011	5865	3069
4011	6655	3069
4011	6340	3069
4011	6810	3069
4011	5785	3069
4011	6025	3069
4011	5080	3069
4011	6025	3069
4011	4860	3069
4011	6730	3069

Fig. 17: Recorded ASCII data

During every new establishing of a connection by means of a click onto "Connect!" and a marked "Save", a new data file (a separate one for every module) in the ASCII format with the file extension *.asc is automatically generated in the working directory of the ModuleConfigSuite. For this purpose, it does not matter whether you are in the single-mode or in the multi-mode. The file names of the generated files are composed of the module code as well as date and time of the beginning of the recording. Consequently, the file name “M3_110406_114231.asc“ designates a data recording of the module 3 that started on 11th April 2006 at 11:42:31 a.m.
For safety reasons, the data are stored only in the corresponding mode (single-/ multi-) respectively in the single-mode only for the module just selected. If, for example, the storing is marked for all 4 modules in the multi-mode, only a storing of the data in the file of the corresponding chosen module is carried out in the single-mode and no (background) storing of the data of all 4 modules is executed. Single-mode and multi-mode store to the same data file of the respective module.

8 Maintenance Service and Repair by the After-Sales Service Division

According to the general terms and conditions of sale and delivery, WARRANTY is furnished for the device provided by the manufacturer. If malfunctions or damages occur at the device during the warranty period warranty is given for according to the terms and conditions of warranty, the manufacturer shall execute the repair or the replacement of defective components after a prior examination.

The manufacturer shall be responsible for the device in its original configuration.

Only the manufacturer shall be authorized to carry out all and any interventions that concern the device, the structure, the software, or the operating cycle of the device or these interventions exclusively require the express prior consent of the manufacturer.

Attention

The environmental conditions agreed in the contract must be met.

The manufacturer shall not be liable for any damages owing to the improper or false utilization of the device as well owing to damages arising from interventions to the device that are not expressly required in the present manual.